

The Role of Scapular Stabilization in Shoulder Function and Rehabilitation

An Honors Thesis (HONRS 499)

by

Robin R. Whisman

Thesis Advisor
Dr. Thomas Weidner

Thomas J. Weidner

Ball State University

Muncie, Indiana

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Abstract

Three of the four articulations that comprise the human shoulder complex directly involve the scapula. The scapula must not only move with the humerus to facilitate full range of motion of the shoulder, but must also serve as a solid base from which the upper extremity can work. Scapular stabilization is imperative for proper functioning of the shoulder complex. The following thesis includes a discussion of the anatomy and biomechanics of the shoulder complex, the role of faulty scapular stabilization in shoulder pathology, and rehabilitation techniques that specifically address scapular stabilization. Following this discussion is an extensive presentation of scapular stabilization exercises, including pictures and descriptions of the exercises being performed.

Acknowledgments

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Of all the joints in the human body, none is more complex than the shoulder. The shoulder complex is composed of four articulations: the sternoclavicular, acromioclavicular, glenohumeral, and scapulothoracic. Since three of these four articulations directly involve the scapula, it is evident that the scapula plays a very important role in shoulder function. The muscles that attach the scapula proximally serve to stabilize it as a solid base from which the upper extremity can function. It is important to understand the role that the scapula and its muscular stabilizers play in normal shoulder function, so as to better appreciate the role that they may play in its dysfunction. It is only through proper functioning of the entire shoulder complex (including scapular stabilization) that a shoulder can be fully functional.

Following, the anatomy and biomechanics of the shoulder complex are examined. Possible dysfunctions are presented, relating to pathology in varying parts of the complex; and shoulder rehabilitation, focusing on scapular stabilization, is discussed. Following this discussion, appendixes are provided to clarify the relationship between motion of the humerus with that of the scapula, and to give several examples of scapular stabilization exercises. The purpose of this discussion is to give the reader a better appreciation of the role of scapular stabilization, and to provide ideas for incorporating scapular stabilization into all shoulder rehabilitation programs.

Anatomy

Sternoclavicular (SC) Joint

The sternoclavicular (SC) joint is a modified saddle joint comprised of the articulation of the proximal clavicle with the manubrium of the sternum and the cartilage of the first rib. It is the only point of attachment of the upper extremity with the trunk (Andrews, Harrelson, & Wilk, 1998). The SC joint is weak because of its incongruent bony arrangement, but it is supported by ligaments. These ligaments serve to hold the SC joint together and to help support the weight of the shoulder and upper extremity (Hall & Brody, 1999; Prentice, 1998; Starkey, 1996). The joint contains a fibrocartilaginous disk that functions as a shock absorber (Starkey, 1996). Movement occurs at this joint as a result of movement at the clavicle's distal attachment to the acromion of the scapula (Kisner & Colby, 1996).

Acromioclavicular (AC) Joint

The distal end of the clavicle articulates with the acromion process of the scapula, forming the acromioclavicular (AC) joint. It is supported by the acromioclavicular and coracoclavicular ligaments (Kisner & Colby, 1996). These ligaments add stability to the joint while at the same time allowing the clavicle to rotate along its longitudinal axis, facilitating elevation of the upper extremity (Prentice, 1998). The acromioclavicular joint is affected by rotation, tipping, and winging of the scapula (Kisner & Colby, 1996).

Glenohumeral (GH) Joint

The glenohumeral (GH) joint is the most mobile and the least stable of all the joints in the human body (Andrews, Harrelson, & Wilk, 1998). It is formed by the

approximation of the large head of the humerus with the small glenoid process of the scapula. The articulation of the GH joint has been compared to that of a golf ball on a tee (Rehabilitation Institute of Chicago, 1998). The shoulder's extreme mobility is the result of this large ball-small socket arrangement, where only a small part of the humeral head actually comes in contact with the glenoid fossa at a given time (Kisner & Colby, 1996). This arrangement is optimal for range of motion, but this increased mobility comes at the expense of stability. The GH joint has a lax joint capsule, and relies on a combination of bony anatomy, ligaments, muscle tendons, and the glenoid labrum for stability (Kisner & Colby, 1996).

Kisner (1996) states that static stability of the glenohumeral joint is provided by the bony anatomy, ligaments, and glenoid labrum. The glenoid fossa provides some stability because it is oriented in an anterior, lateral, and upward-facing position. The ligamentous supports include the coracohumeral and superior, middle, and inferior glenohumeral ligaments. The labrum is a fibrocartilaginous rim that deepens the glenoid fossa and serves as an attachment for the joint capsule.

Dynamic stability is provided by the rotator cuff, biceps, triceps, and deltoid muscles and tendons. The glenohumeral joint capsule is lax, but can be slightly tightened by contraction of the rotator cuff muscles.

Scapulothoracic (ST) Joint

The scapulothoracic joint is the articulation of the concave anterior surface of the scapula with the convex posterior surface of the rib cage (Hall & Brody, 1999). It is not a true joint because it lacks a joint capsule and is not a bone-on-bone articulation (Hall &

Brody, 1999; Starkey, 1996). The scapula is free-floating on the back of the trunk, and is held in place primarily by atmospheric pressure (Andrews, Harrleson, & Wilk, 1998). Its only ligamentous support comes from its articulation with the clavicle at the acromioclavicular joint. Although it is not a true joint, motion at the scapulothoracic junction is essential for proper function of the shoulder complex. The scapula moves in several directions, including; elevation, depression, upward and downward rotation, protraction or abduction, retraction or adduction, winging, and tipping (Kisner & Colby, 1996). Although the majority of the shoulder's range of motion comes from the glenohumeral joint, scapular motion is needed to facilitate full range of motion.

Shoulder Biomechanics

The scapula and the muscles attached to it serve as a transition point between the trunk and the upper extremity. Because the only connection the upper extremity has with the axial skeleton is through the SC joint, the scapula and its musculature must serve as the primary source of stability. The muscles that control the position of the scapula serve two basic functions. First, they must be able to fixate the scapula against the thoracic wall to provide a solid base from which the upper extremity can function. Second, they must coordinate motion of the scapula, and therefore the position of the glenoid fossa, with that of the humerus to facilitate full range of motion and function of the shoulder complex (Starkey, 1996). Musculature, in general, adds to joint stability by acting in force couples around a joint. Coactivation of the agonist and antagonist will cause low net torque but high control of motion (Rehabilitation Institute of Chicago, 1998). This effect

is seen often in the scapular stabilizing muscles. In a dependent position, the scapula is stabilized primarily through a balance of forces from the upper trapezius, levator scapulae, and the weight of the arm in the frontal plane, and between the pectoralis minor and rhomboid and serratus anterior in the transverse and sagittal planes. Stabilizing muscles are also used to eccentrically control motion in the opposite direction (Kisner & Colby, 1996).

Every motion of the GH joint incorporates movement or stabilization of the scapula. The purpose of scapular motion is to keep the glenoid fossa in such a position that the center of humeral rotation is as close as possible to the same position throughout the entire range of motion (Brownstein & Bronner, 1997). The way the glenoid fossa moves in reaction to the movement of the humeral head has been compared to a seal balancing a ball on its nose; the glenoid fossa reacts to and follows the movement of the humeral head much like a seal would move its nose in reaction to the movement of the ball (Rehabilitation Institute of Chicago, 1998). Scapular motion serves to maintain good length-tension relationships of the muscles moving the humerus and good congruency of the humeral head and glenoid fossa while reducing shear forces (Kisner & Colby, 1996).

Appendix A shows the scapular motions as they relate to movement of the GH joint. The scapula is capable of eight directions of movement: protraction (abduction), retraction (adduction), upward rotation, downward rotation, elevation, depression, tipping (of the inferior angle), and winging (of the vertebral border). Protraction and upward rotation are associated with both flexion of the GH joint and activities involving pushing. Scapular protraction is the primary action of the serratus anterior. With

serratus anterior atrophy or inhibition secondary to long thoracic nerve pathology, the vertebral border will “wing” away from the thoracic wall. Winging scapulae become prominent during pushing activities. Scapular winging is also present during horizontal adduction of the humerus (Kisner & Colby, 1996). Kisner & Colby (1996) state that upward rotation of the scapula is an action of the upper and lower trapezius, serratus anterior, and pectoralis minor. Upward rotation of the scapula cannot be isolated without associated movement of the humerus, but lying down with the arm above the head and trying to lift the arm causes the upward rotators to contract. The pectoralis minor is also responsible for tipping the scapula so that its inferior border lifts off the thoracic wall. Tipping of the inferior angle of the scapula is necessary to reach the hand behind the back with internal rotation and extension of the humerus.

The scapula is retracted and downwardly rotated during extension of the GH joint and pulling activities. The rhomboids and middle trapezius (with the latissimus dorsi, teres major, and rotator cuff muscles) are responsible for these motions. Scapular elevation is an action of the levator scapulae, trapezius, rhomboids, and the upper fibers of the serratus anterior. The lower third of the trapezius and the lower fibers of the serratus anterior depress the scapula.

The scapula must move with the humerus to facilitate full abduction of the arm. The movement of the scapula relative to glenohumeral movement is referred to as scapulohumeral rhythm. Prentice (1998) gives a detailed description of scapulohumeral rhythm throughout the full range of shoulder motion; he states that the GH joint is solely responsible for the first 30 degrees of abduction. In the range from 30 to 90 degrees, the

scapula upwardly rotates 1 degree for every 2 degrees of motion at the GH joint. From 90 degrees to full abduction, the scapula moves 1 degree for each degree of GH movement. Without proper scapulohumeral rhythm, compensatory measures that predispose a person to injury will be displayed.

Shoulder Dysfunction

The scapula must serve as a solid base from which the arm can work, while at the same time, move in conjunction with the humerus to facilitate full range of motion and function of the upper extremity. It is important that the scapular muscles are able to function as stabilizers and also able to coordinate the movement and position of the scapula with that of the humerus to facilitate full function and reduce the incidence of injury. The functioning of the scapular muscles is directly related to that of the muscles acting on the humerus. With faulty scapular posture from muscular imbalances, muscle length and strength imbalances also occur in the humeral muscles, altering the GH joint (Kisner & Colby, 1996). Any alteration in the normal functioning, or pathomechanics, of the GH joint increases the incidence of irritation, inflammation, and injury.

The scapula must move so the glenoid fossa maintains its relationship with the moving humeral head. Shoulder dysfunction is often caused by overuse or weakness of the muscles that attach the scapula proximally (Brownstein & Brody, 1997). Without positional control of the scapula, the efficiency of the humeral muscles decreases (Kisner & Colby, 1996). The inability of the scapula to maintain a normal stabilizing effect and association with the glenohumeral joint and related musculature is referred to as scapular

dissociation. This condition leads to altered upper extremity kinematics (Brownstein & Bronner, 1997). The Rehabilitation Institute of Chicago (1998) explains that weakness of the scapular stabilizers breaks the kinetic chain; it disrupts the funneling of velocity and force, and does not allow for a stable base from which the arm can work. They also report that scapular muscle failure appears in 68-100% of shoulder pathology. Causes of instability can include pathology of the glenohumeral joint or of the long thoracic or spinal accessory nerves. Thoracic outlet syndrome is often accompanied by weakness of the scapular adductors and upward rotators (Kisner & Colby, 1996). The most common etiology for scapular dyskinesis is muscle inhibition secondary to some other pain generator (Rehabilitation Institute of Chicago, 1998).

Any deficiency in scapular control will lead to altered mechanics of the GH joint. Faulty scapular retraction during glenohumeral abduction will cause forward translation of the humeral head to allow the arm to travel behind the frontal plane (Hall & Brody, 1999). Trapezius, rhomboid, and serratus anterior weakness impairs the scapula's ability to position itself as a congruent socket for the moving humerus; to stabilize itself as an anchor for origins of rotator cuff, deltoid, biceps, and triceps; and to move smoothly from retraction to protraction in throwing. Upper trapezius weakness leads to a lack of acromial elevation, and increases impingement with abduction (Rehabilitation Institute of Chicago, 1998). If the upward rotators (upper and lower trapezius and serratus anterior) are weak or paralyzed, the scapula will be rotated downwardly by the deltoid or supraspinatus during abduction or flexion. Functional elevation of the arm will be unable to be reached even though there is full passive range of motion and normal strength of the

flexor or abductor muscles (Kisner & Colby, 1996). Faulty upward rotation will cause an inappropriate length-tension relationship of the deltoid (Hall & Brody, 1999). This will alter the deltoid-rotator cuff force couple, allowing the humerus to translate superiorly, impinging the subacromial structures (Hall & Brody, 1999).

Lack of scapular stabilization and control can cause impingement, inflammation, and tendinitis of the subacromial structures. Healthy individuals and athletes (especially those who engage in repetitive overhead activity) should perform exercises that focus on maintaining strength of the scapular stabilizers to avoid development of chronic shoulder pathology. Scapular stabilization should also be included as a central focus in the rehabilitation of any shoulder injury.

Rehabilitation

Scapular stabilization plays an intricate role in maintaining proper functioning of the upper extremity and should therefore be incorporated into any upper extremity rehabilitation program. Brownstein and Brody (1997) state that the goal of upper extremity rehabilitation is to minimize errors in activity by improving strength, stability, and motor control of the injured extremity. Error is minimized by maximizing sensory input (including vision and proprioception), knowing the joint's position in space, and having stable proximal joints (including GH, scapula, trunk, and lower extremity). They suggest three areas of focus for shoulder strengthening, including scapular balancing muscles (upper and lower trapezius, serratus anterior, rhomboids), humeral head

depressors (subscapularis, infraspinatus, teres minor), and prime humeral positioners (deltoid, pectoralis major, latissimus dorsi).

Rehabilitation should first focus on gaining range of motion. After restoring full range of motion, and before beginning strengthening, the focus of rehabilitation should be on movement, timing, mechanics, and movement patterns (Brownstein & Brody, 1997). This is when scapular stabilization and scapulohumeral rhythm should be addressed. Brownstein & Brody (1997) suggest that the four exercises that compose the core of shoulder rehabilitation include scaption, rowing, push-ups+, and press-ups. They suggest a combination of open and closed kinetic chain exercises to facilitate joint proprioceptors' enhancement of stability and dynamic muscular control. Appendix B has several examples of both open and closed kinetic chain exercises that address scapular stabilization.

Adding compression to the glenohumeral joint may improve the ability of the scapula and rotator cuff muscles to fire appropriately, but will not have the same effect if the scapula is unstable (Brownstein & Brody, 1997). The Rehabilitation Institute of Chicago (1998) states that closed kinetic chain exercises promote coactivation of force couples, which enhances the muscles' primary role as stabilizers. Proprioceptive activity is enhanced by emphasis on stability and coactivation. Fixing the hand allows more muscle activity at the scapula. They contend that closed kinetic chain exercise results in loads and activation levels safe enough for early rehabilitation (muscles firing at 10-40% of max), and should be used early in the rehabilitation process to obtain a strong scapular base.

Rehabilitation should progress in terms of endurance, eccentric training, plyometric (stretch-shortening) drills, and speed; and scapular stabilization exercises should progress

from lying (trunk supported, concentrating on shoulder and scapular motions) to sitting (with good posture) to standing, and then on to functional activities (Kisner & Colby, 1996). The maximum load on the scapular stabilizers occurs when the arms are abducted to 80-90° with maximum glenohumeral internal rotation. (Rehabilitation Institute of Chicago, 1998). Scapular stabilizers may take two to three months to restore (Rehabilitation Institute of Chicago, 1998).

Summary

Proper functioning of the upper extremity depends on the scapula to provide a solid base from which the arm can work, and to move in conjunction with the humerus to facilitate full range of motion. A scapula that is unstable, or that does not move in synchrony with the humerus can lead to impingement and tendinitis of the subacromial structures in the shoulder. Scapular stabilization exercises should be included in any rehabilitation program for injured shoulders, and also in prevention or maintenance programs for shoulders that are healthy.

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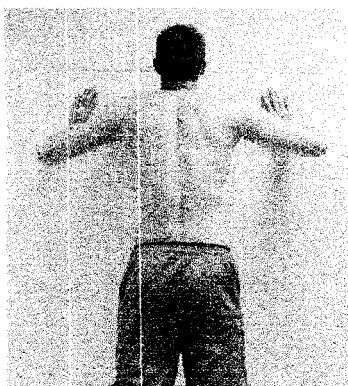
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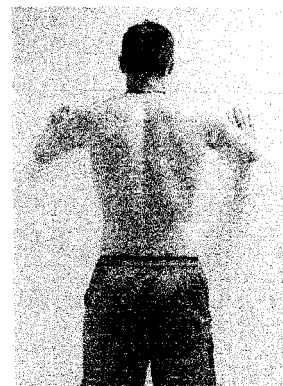
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Appendix A:
Humeral and Scapular Motion Table

Motion of Humerus	Associated Motion of Scapula
Flexion	Upward Rotation, Protraction
Extension	Downward Rotation, Retraction
Abduction	Upward Rotation
Adduction	Downward Rotation, Winging
Internal rotation	Protraction
External rotation	Retraction

**Figure 1**

Standard wall push-up.
This exercise can be made more difficult by incorporating a push-off from the wall between each repetition.

**Figure 2****Figure 3**

Wall push-ups may also be performed in a corner (figure 3), or on a corner (figure 4). These should be performed as plyometrics, with a push-off and alternation of hand positions between repetitions.

**Figure 4****Figure 5**

Figure 5 shows wall push-ups incorporating an elastic band around the wrists to increase the load on the scapular stabilizers. This exercise should also be performed with a push-off and alternation of hand positions between repetitions.

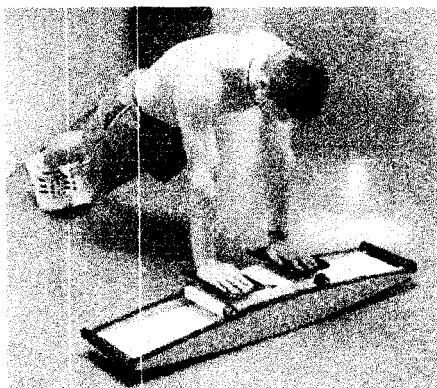


Figure 6

Upper extremity exercises using the Fitter.

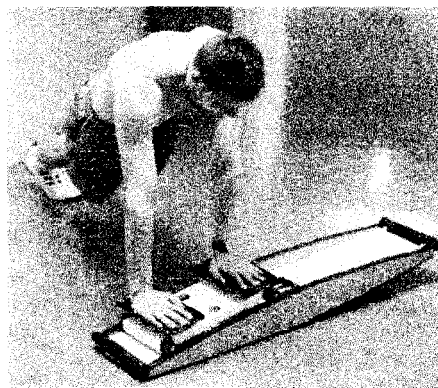


Figure 7

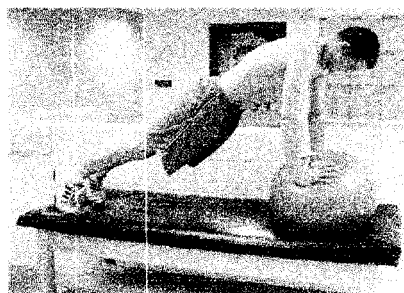


Figure 8



Figure 9

Figures 8 & 9 show push-ups on a Swiss ball. Scapular stabilizers must fire to stabilize the weight of the body on the ball during the exercise.

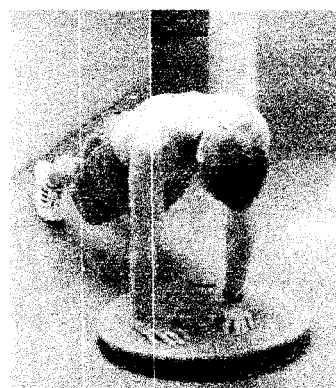


Figure 10

Push-ups on the BAPS board. Push-ups must be performed while balancing the board, and not letting any of the edges touch the ground.



Figure 11



Figure 12

Figure 12 shows step-ups for the upper extremity. The athlete can progress from this exercise to using a stairclimber as shown in figure 13.



Figure 13



Figure 14

Figure 14 - press-ups.

The exercise shown in figure 15 requires the athlete to incorporate core trunk stabilization along with scapular stabilization to maintain this position on the Swiss ball.

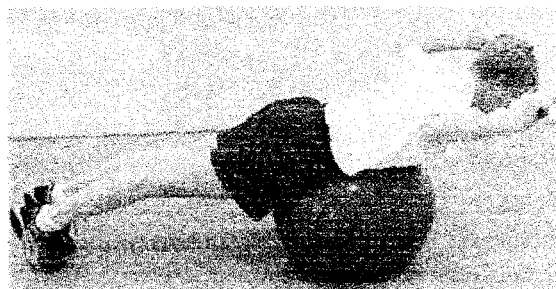


Figure 15

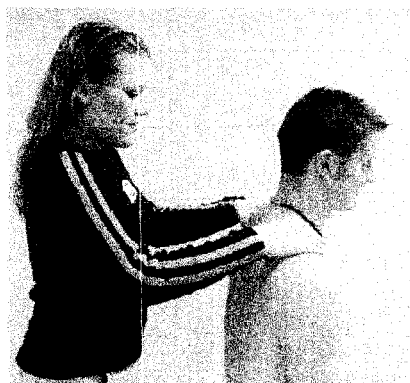


Figure 16

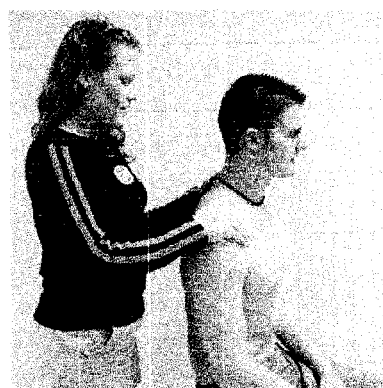
Figures 16 & 17 show scapular stabilization MREs. This exercise should progress from lying, with the hand fixed on the table, to standing with the hand fixed on the wall.



Figure 17

**Figure 18**

Scapular elevation MRE. Shoulder shrugs are performed against resistance. This exercise strengthens the upper trapezius and levator scapulae muscles.

**Figure 19****Figure 20**

Scapular anterior elevation MRE. Patient is instructed to lift the shoulder and bring it forward toward the nose.

**Figure 21****Figure 22**

Scapular posterior elevation MRE. Patient is instructed to lift the shoulder toward the back of the head.

**Figure 23**

**Figure 24**

Scapular depression
MRE.

**Figure 25****Figure 26**

Shoulder flexion
MRE using an
elastic band around
the arms to increase
load on scapular
stabilizers.

**Figure 27****Figure 28**

Scapular protraction
MRE.

**Figure 29**



Figure 30

Scapular retraction MRE.



Figure 31



Figure 32

MRE in the D1 pattern (moving into extension).



Figure 33



Figure 34

MREs in the D2 pattern. (moving into flexion).



Figure 35



Figure 36

Rhythmic stabilization.
Figure 36 - at 90 degrees of
shoulder flexion.
Figure 37 - at 45 degrees of
shoulder abduction and 90
degrees of elbow flexion.



Figure 37

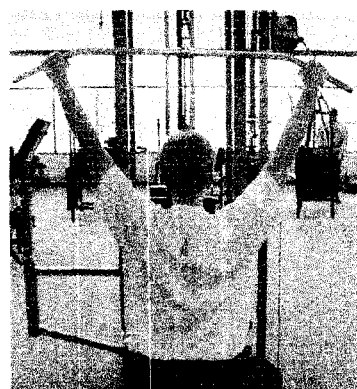


Figure 38

Lat pull-downs.

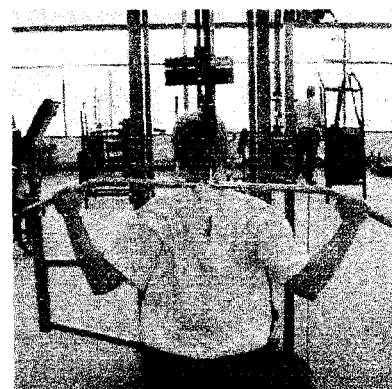


Figure 39



Figure 40

Horizontal rows with elastic band for
resistance. The scapulae are retracted
as the arms are horizontally abducted.

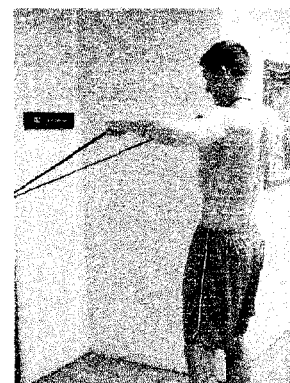


Figure 41



Figure 42

Bilateral shoulder external rotation with an elastic band for resistance. The athlete should focus on keeping the scapulae pinched together throughout this motion.

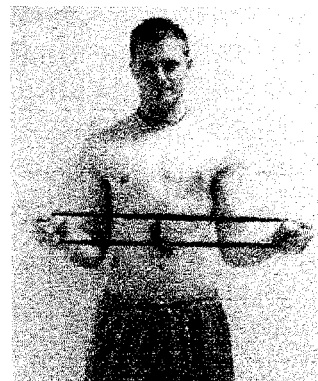


Figure 43

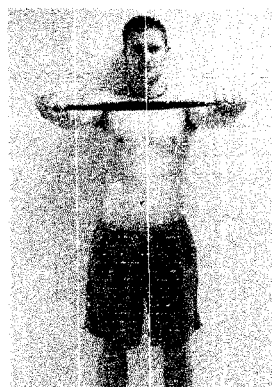


Figure 44

Bilateral horizontal abduction with an elastic band for resistance. The scapulae should be retracted (adducted) as the arms are moved into horizontal abduction.

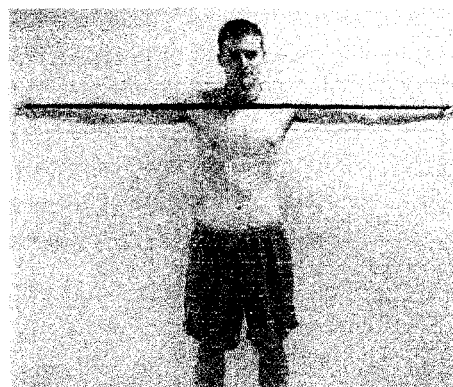


Figure 45

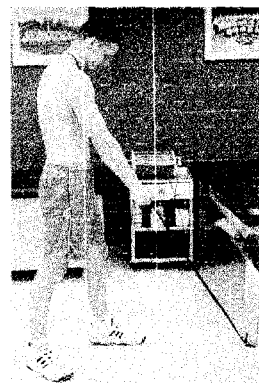


Figure 46

“Lawnmowers” with an elastic band. The scapula is retracted as the arm is extended.

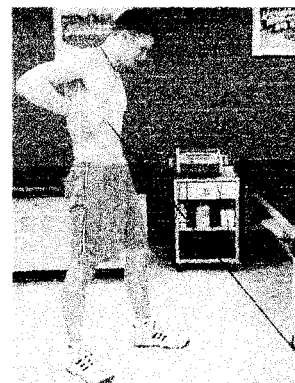
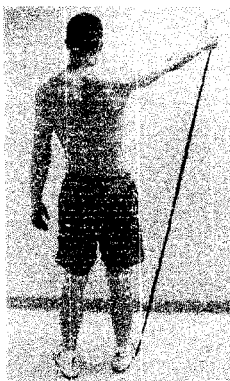
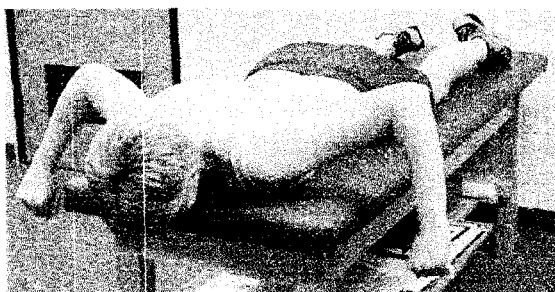


Figure 47



Scaption with an elastic band. Scaption is abduction in the plane of the scapula (30 degrees anterior to the frontal plane).

Figure 48



Prone open kinetic chain (OKC) exercise for the rhomboids. The scapulae are adducted to horizontally abduct the arms. Weights or elastic bands may be used to increase difficulty.

Figure 49

OKC exercise for the middle trapezius. This exercise may also be performed with weights or elastic tubing.

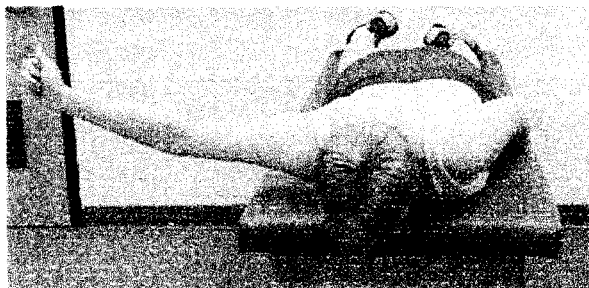


Figure 50



Figure 51

OKC exercise for the lower trapezius. Progress exercise by adding weights or elastic tubing.